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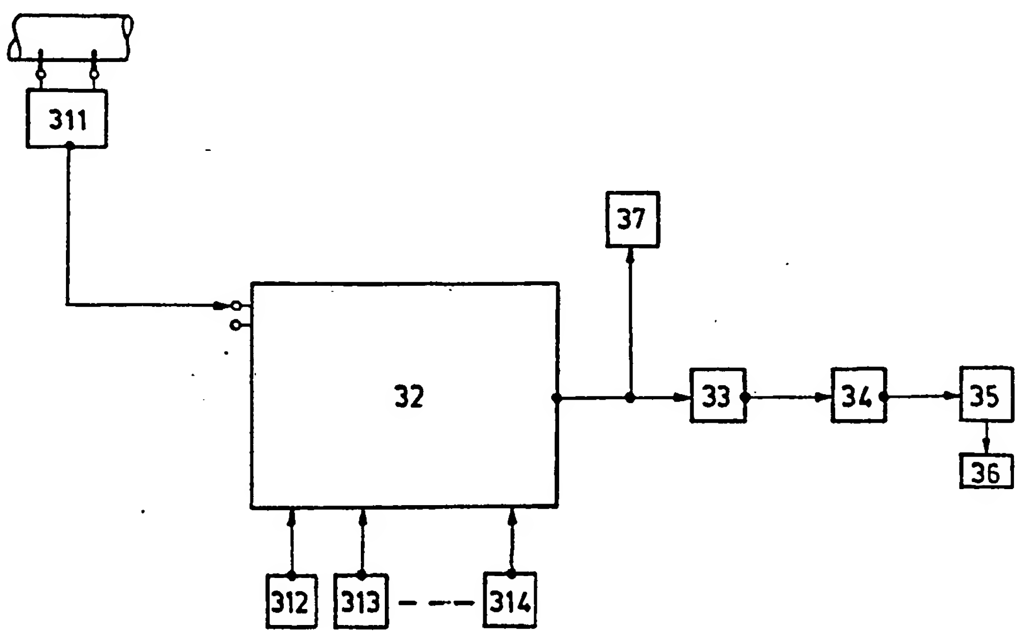
IDS

(54) Title: A METHOD FOR MEASURING THE CONSUMPTION OF FLUIDS OR FLUID-BORNE HEAT ENERGY AND A METER FOR PERFORMING SAME




(57) Abstract

The consumption of fluids or fluid-borne heat energy supplied over a pipe system is indirectly measured by a new method which may preferably be performed by a new meter. It has been found that all data required for an optimum process control of the supply and for billing the supplied quantities can be derived by a very simple data processing operation from a single physical quantity, viz. the dynamic differential pressure sensed in two characteristic cross-sections of the fluid transporting pipe. The new meter comprises at least one pressure transmitter, a data processing unit coupled to the transmitter and working according to the said relations between differential pressure and the wanted data, and data recording and displaying and/or transmitting means.

# A METHOD FOR MEASURING THE CONSUMPTION OF FLUIDS OR FLUID-BORNE HEAT ENERGY AND A METER FOR PERFORMING SAME

The invention is related to consumption measuring, viz. establishing the amount of a fluid or fluid-borne heat energy that has been consumed in the course of a technological process or supplied by public services such as waterworks or district heating plants. A new method has been conceived which is preferably performed by using a new meter offering the advantage that

- it is sufficient to measure only a single physical quantity by contacting sensors with the fluid transport channel without disturbing the working conditions of the latter one, and
- though only a very simple data processing device is used, the data obtained by an indirect measurement of the wanted quantities may immediately be displayed in the wanted dimensions, the said data may also be collected and stored and/or further processed at the very spot and/or transmitted to external processing and/or process control means.

The supply of fluids such as water and of fluidborne heat energy is in industrial processes as well as in the supply of the needs of the population a task of very high social importance incurring very high expenditure. Consequently, it is also very important to perform the following tasks in any field of social activity:

- establishing the amount of fluid consumption or heat consumption individually for each consumer /be it an industrial plant, a public building, the individual dweller of a lodgement or a certain community of dweller/;

- preparing the bill in consideration of the consumption within a certain period /hereinafter shortly referred to as billing/;
- keeping evidence of the collected data /consumption quantities, items of the bill, etc./.

Another very important task is the control of the fluid flow in order to achieve optimum working conditions and avoid as far as possible any superfluous consumption such as overflow or heat loss without thereby affecting the undisturbed supply of the wanted quantities. Such a process control is usually performed by applying control signals which represent either the quantity already consumed or the deviation of the transported volume from the optimum, respectively. Such control is of a continually increasing importance especially since the economizing of energy is recently more and more laid stress upon. It can be seen that the amount of consumption is the basis for both the billing of supply and the optimizing of consumption. It would therefor be reasonable and this is the object of our invention to obtain all information necessary for both billing and controlling from a single signal proportional to a single physical quantity.

The different measuring operations providing on the one hand the basic data for billing and evidence and on the other hand the said control signals are, however, up till now performed in quite different ways and even the different methods for one and the same purpose are differing from each other dependent on the local requirements and working conditions such as the character of the very spot the measurement may be performed at or the design, shape, construction of the given transport channel /pipe system/ etc.

It can be seen that the problem is sophisti-

cated and may be discussed from many aspects. For reason of better understanding, we will discuss the problem in connection with a particular field of application but it will be obvious for persons skilled in the art that similar ponderations will take place in any field of application if, among others, the amount of fluid supply and/or fluidborne heat supply shall be established.

The field in question is a communal supply service where there is a need of measuring

- on the one hand the heat energy consumption in a district heating plant in a manner that the consumption of any individual consumer or even any of his heat exchangers may be specified individually and also the summerized consumption of a greater unit may be established, and
- on the other hand the water consumption in any of the lodgements which shall, if necessary, individually be specified even for each water-tap and also summarized in any wanted relation.

The measuring of the consumed heat energy may according to prior art be performed in different ways.

It is e.g. usual to measure on the one hand the quantity of heat carrying fluid which has flown through a particular cross-section of a heat exchanger and on the other hand the temperature difference between the fluid input and output of the said heat exchanger so that the heat energy consumption may be calculated by multiplying the said data with each other, and, if necessary, modifying the product for the specific heat of the carrier fluid /the carrier is usually water with a specific heat of about 1/. This method requires, thus, the independent measuring of two different physical quantities, viz. temperature diffe-

rence and mass flow.

Another method consists in measuring only the temperature difference and multiplying same by a constant value representing all other quantities to be taken into consideration.

A device has been developed based on the principle of evaporation but there arises an important heat loss and the device is also delicate for both the manufacturing and application aspects so that its widespread use can hardly be reckoned with.

The different heat consumption measuring devices belonging to prior art and used in the industrial practice are aside from their particular shortcomings showing some common disadvantages:

- the device may only be contacted with the fluid flow by disrupting the pipe system at a given spot; this is especially disadvantageous if a working plant shall afterwards be equipped for a more particular consumption measuring and/or controlling but the insertion of any of the known means into a fluid transport path is usually disadvantageous even in case of plants yet to be built;
- most of the known devices are equipped with one or more moving elements the disadvanteges of which being well-known;
- the temperature measurement can in such systems generally not be performed with the severe accuracy as required;
- in case of extensive systems, the transmission of data is subject to an inertia-caused time delay;
- the subsequent insertion of a measuring device into working systems requires their transitory standstill;
- the known devices apt for this purpose are usually relatively extensive and intricate.

The application of the known devices is also

often restricted by the dimensions of the connecting path, e.g. the diameter of the pipe etc.

Some methods according to prior art are producing data based on the instant state of a few distinct spots and then extending the evaluation of such data to the whole system though the features of the said methods do not justify such an extrapolation.

The accuracy generally presumed in thermodynamic equations /where the error is not expected to exceed in infinitely small value/ can, thus, not be obtained and a finite inaccuracy must be reckoned with. We do therefor in our following discueesion of prior art refer to the change ratio of functions and not to their differential quotient.

The shortcomings of the known methods and the tendency of the usual developing activities have up till now prevented a more detailed collecting of heat supply data in the framework of an extensive entity such as a group of buildings or a residential estate; the consumption has been and is only established as an average value for the whole entity and not specified particularly for each single lodgement let alone the single heat exchangers within a lodgement. Bills are usually issued specifying a lump sum based on the said average; it goes without saying that such roughly estimated values can not be used for generating control signals in an optimum control system aiming at energy economy.

It will now be scrutinized how could be performed a more detailed data collecting on heat and/or water consumption if using methods according to prior art.

Let us begin with the heat supply and take a dwelling comprising five heat exchangers /radiators/. The basic data for the billing be measured at each

single heat exchanger and then summed up for the dwelling as a whole and the resulting consumption of a central unit supplying among others also the said dwelling shall also be obtained.

According to one of the above mentioned methods, the fluid temperature shall be measured at the fluid input and output of each heat exchanger /~~at a certain cross-section of the pipe system~~ each/, the ~~temperature difference~~ $\Delta T$ shall be reckoned and then multiplied by the also measured value of the mass flow /with heat carriers other than water, the product should also be modified by the specific heat of the carrier fluid/; the product is representing the heat consumption within a time unit /summing up these values for a certain period would produce the whole consumption/: $\Delta Q/\Delta t = \Delta m/\Delta t : C_p \cdot \Delta T$, where $\Delta Q/\Delta t$ =the heat supply reckoned for a time unit; $C_p$ = the specific heat of the heat carrying fluid and $\Delta m/\Delta t$ = the quantity of fluid flowing through a certain cross-section during a time unit. The temperature measuring may be performed by any known method.

The known devices used for measuring the fluid flow may work on a mechanical principle, they may be based on electro-mechanical conversion, and contractless devices may also be used; there are among others devices converting the rotation of a propeller into an electric signal, capacitive sensors, sensors based on the eddy current phenomenon or utilizing the magnetic momentum, etc.

According to another method, only the temperature difference is measured and then multiplied by a constant value factor presumed to represent all other system features as though there were only constant, unchanging quantities to be taken into consideration; the formula reads: $Q = B \cdot \Delta T$, where Q is the heat con-

sumption and B = A . K where A is the cross-section of the fluid transport path /pipe/ and the factor K /the system factor/ incorporates all other system features. The shortcoming of this method is obvious: only the change of temperature is measured and also such features of the system are considered constant values which are really variable quantities; only the cross-section A, the specific heat $C_p$ of the carrier and its static density are really constant quantities. An especially uncertain factor is the value of the carrier velocity and just this quantity is a deciding factor when estabilishing the value of the mass flow.

It can be seen that the known methods are either providing rather inaccurate data or requiring the performance of more measurements of different kind; the greater part of the devices used for measuring the mass flow are inserted into the transport path in a disturbing manner whereas the use of the known contactless sensors is unbearable for economic reasons.

The invention is based on the conception that the different data necessary for performing the above specified tasks such as billing, process control, keeping evidence and the like can be provided in a relatively simple and inexpensive manner by measuring a single physical quantity which

- is unambiguously related with all quanatities to be established and
- can be measured by sensors directly contacted with the flowing fluid medium in a manner not disturbing the working conditions of the transport path.

Such a physical quantity is the difference between the pressure values sensed in two characteristic cross-sections of the pipe system during the mass flow. This quantity is properly speaking the dynamic differential pressure since all static components being

equal in both cross-sections are eliminated when producing a signal representing the difference between the said pressure values. The sensors used in the methods according to prior art are usually contacted with the flowing fluid medium in a manner disturbing a working conditions whereas the differential pressure may be measured by just tapping the pipe wall over a very small boring not interfering with the fluid flow in any way the leakage being of an incommensurabily small value. The sensors of some of the known differential pressure gauges may, e.g. be adjusted to the pipe wall by the well known injecting method used for fixing rivets, pins and the like into the wall.

The relation between the supplied heat energy, the mass flow, and the differential pressure will hereinbelow bet set forth particularly. It can be seen that the measuring of neither the temperature nor the mass flow will be needed any longer once the data representing the differential pressure will be at our disposal. The value of the differential pressure $\Delta P_{din}$ is directly representing also the heat loss but the other physical quantities components of the resulting formula for heat loss can also be derived therefrom considering that there is also an unambiguous relation between the mass flow and the differential pressure.

It goes without saying that the amount of water supply, viz. the amount of water flowing through a certain cross-section of a pipe can also be derived from the differential pressure by use of known and cheap data processing means; the single physical quantity obtained by a slight, undisturbing interference with the pipe wall for performing the indirect measurement provides all information necessary to establish the heat supply and/or the fluid supply of a system and even other important features of the system such as the

ratio of static and dynamic pressure and their changes during work and the like which may be useful for process control and/or other purposes. If, e.g. a pipe section ending in a water-tap is in two different cross-sections lying near to each other subjected to the said pressure sensing, the water supply of either a cold water-tap or a hot water-tap can immediately be established.

It is a special advantage of the method according to the invention that consumption meters performing same can manifold be designed adjusting them to different systems and for different purposes. They may be arranged even at each heat exchanger and each water-tap of a dwelling at very small expenses and space requirement, and the output signals of the said meters may preferably over a wire connection be transmitted to a common data processing device of similarly small space requirement and simple construction the said data processing device being in a known manner embodied for any wanted purpose, viz. to be able to derive any wanted other quantity from the single input signal representing the said differential pressure.

The invention will now be set forth more particularly with reference to the attahced drawings.

Figure 1 is illustrating the consumption measurement as used in a district heating system by meters arranged in a dwelling,

Figure 2 is showing the water consumption measurement performed by sensing the differential pressure in a pipe section ending in a water-tap,

Figure 3 illustrates the processing of the output signals of a differential pressure gauge which will hereinafter be referred to as pressure transmitter.

It can be seen in Figure 1 that the heat

carrying fluid is flowing through the central unit 11 and then distributed - among others - between the heat exchangers 11i /i = 1-5/ arranged in the dwelling. A pressure transmitter 12, 12i is arranged at each heat exchanger 11i and also at the central unit 11 providing output signals proportional to the pressure difference between the fluid input and output of the given heat exchanger. The data measured with the radiators are transmitted through the wire 142 to the data processing unit 132 whereas the data measured with the central unit 11 are transmitted through the wire 141 to the data processing unit 131.

It can be seen at Figure 2 that the pressure transmitter 22 is over its sensors coupled to the pipe section 21 ending in a water-tap at two different cross--sections 211 and 212 /spaced of each other at a distance L/, and the transmitter 22 is connected to the data processing unit 23; the latter one is storing and displaying the measured data but also utilizing them for the supply control system deriving from the said signals the values of the controlled variable and generating the control signal for an actuator 24 such as a valve in accordance with the error value.

Figure 3 illustrates the data processing. It can be seen that the said data processing units 131, 132, 23 are comprising an arithmetical stage 32 each to the input/s/ of which is coupled at least one pressure transmitter 311 in direct or indirect connection whereas one or more DC-signal sources 312, 313, 314 are coupled to further inputs of the arithmetical stage 32 the said DC-signals representing constant value system features such as the diameter of the pipe, the specific heat of the carrier if different from 1, or the constant values to be taken into consideration if converting the measured quantity into any other kind of related quantities. In the shown preferred embodiment,

an A/D converter such as voltage /pulse train converter 33 is coupled to the output of the arithmetical stage 32 followed by a pulse counter 34. A display means showing the instant value of the stored sum may be integrated into the pulse counter 34 but it may also be expedient to use a special data recording device, e.g. a data printer or a numerical data recorder 35 coupled with a numerical display device 36. A separate output of the arithmetical stage 32 or the A/D converter may be coupled to a further device such as an instant value display 37 showing the instant value of heat or water supply /flow intensity/ or the separate output may be coupled to an external data processing system or the process control system referred to when explaining Figure 2, e.g. to its actuator 24. The arithmetical stage 32 can be provided with different outputs one of them being coupled to the input of the A/D converter. The data processing unit 131, 132, 23 may also be a multi-purpose device or the units 131, 132, 23 may be integrated into a common one so that the hot water consumption of a dwelling may be obtained over one of the outputs, another output may signalize the cold water consumption, a further output the heat consumption, etc. Any transmission line of the measuring system may be built in a manner as to carry digital, binary signals, there may be multiwire parallel outputs for signals comprising more than one digit, etc. It is also possible to use a pressure transmitter with an immediate digital output in which case the arithmetical stage 32 is also a digital type device and no subsequent A/D conversion is needed.

How the mutual relations between the measured quantity and the wanted quantities will be discussed in particular.

In order to proceed in accordance with our invention, the heat energy consumption during a time unit /which can subsequently be summed up over the whole working period/ shall be expressed by a formula comprising only a single independent variable, viz. the differential pressure $\Delta P_{din}$.

The known equation: $\Delta Q = K \cdot \sqrt{\Delta P_{din}} \cdot \Delta T$ /wherein the factor K represents the resulting value of different constant value system factors/ is, however, still comprising two /formally/ independent variables and, moreover, the output signal of the gauge is properly speaking proportional to the value of the resulting differential pressure $\Delta P$ including also the static pressure components beside the dynamic differential pressure $\Delta P_{din}$, i.e. to a quantity: $\Delta P = \Delta P_{st} + \Delta P_{sziv} + \Delta P_{din}$, where $\Delta P_{st}$ is the static pressure difference from a given height h /pressure drop/, $\Delta P_{sziv}$ is the pressure difference caused by the pump and $\Delta P_{din}$ is just the wanted variable, the dynamic differential pressure being proportional to the heat radiated by the heat exchangers.

The cited formula for the resulting differential pressure may, however, be reduced to a formula: $\Delta P = \Delta P_{din}$ if a pressure transmitter is used where the static components are not appearing in the output signal.

If, e.g. the differential pressure transmitter is comprising a bridge circuit and the outputs of the strain gauges coupled with two different cross-sections of the pipe are inserted into two different branches of the bridge, respectively, whereas the impedance of a third branch of the bridge circuit is an adjustable one such as a potenciometer, a zero compensation as starting calibration of the bridge will cause the elimination of the static components as far as the output signal of the bridge is concerned and such

an elimination is justified by the reasonable presumption that the instant values of the eliminated static quantities will during work not change and not be affected by the dynamic changes occuring in the system such as a pressure deviation caused by a change in density, or a change in the height of the fluid column caused by a temperature difference.

If such a pressure transmitter is used, its output signal can for justified approximation be accepted as representing the dynamic differential pressure. It is only necessary to restrict the range for the value of $\Delta P_{sziv}$ to the range O-X as shown in the diagram at Figure 1 and this condition can easily be complied with.

Let us start from three well-known equations:

$$\dot{Q} = \dot{m} \cdot C_p \cdot \Delta T \qquad /1.1/$$

$$\dot{m} = \rho \cdot A \cdot v \qquad /1.2/$$

$$\Delta P_{din} = \rho/2 \cdot v^2 \qquad /1.3/$$

Transpositions as usual in the mathematical analysis allow the following statements:

$$v = \sqrt{2/\rho \cdot \Delta P_{din}} \qquad /2.1/$$

$$\dot{m} = \rho \cdot A \cdot \sqrt{2/\rho \cdot \Delta P_{din}} \qquad /2.2/$$

$$\Delta T = 1/\rho \cdot \Delta P_{din} \cdot K' \qquad /3.1/$$

K' is a constant value system factor still including neither the cross-section of the pipe nor the specific heat. Accordingly, the above transpositions allow further a transposition of the equation /1.1/ - reducing it also by $\rho/\rho = 1$ - as follows:

$$\dot{Q} = C_p \cdot A \cdot \sqrt{2/\rho \cdot \Delta P_{din}} \cdot \Delta P_{din} \cdot K' \qquad /1.1.1/$$

For systems using water as heat carrier /with a specific heat of about 1 even in the range of 300-700 °C, the $C_p$ factor may be reduced so that the system factor K' is also including the specific heat and is therefor

indexed differently, be it: $K_o$. The equation /1.1/ will now further be transposed:

$$\dot{Q} = A \cdot K_o \cdot \sqrt{2/\rho \cdot \Delta P_{din}} \cdot \Delta P_{din} \qquad /1.1.2./$$

$$\dot{Q} = K_o \cdot \sqrt{2/\rho \cdot \Delta P_{din}^3 \cdot A^2} \qquad /1.1.3./$$

A somehow intricate further transposition involving also reference to the equation /1.3/ will give:

$$\dot{Q} = \Delta P_{din} \cdot D^3 \cdot \pi/2 \cdot K_o \, /\tfrac{Nm}{s}/ \qquad /1.1.4./$$

Thus, we have for systems where the pressure transmitter allows the elimination of the static components of the differential pressure by zero compensation found a relation where the heat consumption is a function of a single independent variable, viz. the dynamic differential pressure represented by the output signal of the pressure transmitter which can now be processed by mutliplying it with a constant value factor being the product of $K_o \cdot D^3 \cdot \pi/2$. If the heat carrier is other than water, the product will be modified by the specific heat of same, i.e. by another constant value.

All components of the system factor $K_o$ are really constant values and may for any given system easily be defined by persons ordinarily skilled in the art. The diameter of the pipe may vary in different places but it remains always unchanged at a given cross--section of the pipe system and it is usually equal in the fluid input and output of one and the same heat exchanger so that in this case it can even be incorporated into the system factor $K_o$. If the factor $K_o$ is calculated with sufficient accuracy, the measured data may after the discussed processing give quite accurate values of the heat consumption.

A further mathematical analysis will now be discussed in particular allows the developing of the different relations represented by the common factor $K_o$

so that it may for certain applications be replaced by a numeric value dependent on presumed resttictions for various system features. The analysis is starting from the formula /1.2/ and the formula

$$\Delta P = \Delta P_{st} + \Delta P_{sziv} + \Delta P_{din}$$

sothat the obtained constant value is also dependent on the relation of the different static components with the resultant feature. These relations allow, thus, also to derive the static components from the output signal of the pressure transmitter by suitable data processing. A calculation restricted to a system with water carrier showed that the accurate characteristics of the pressure change are expressed by a fourth degree function and that the change in density of the fluid is directly proportional to the change of $P_{din}$. The relation between the mass flow and the temperature can also be developed in the shown manner.

The ponderations set forth hereinabove allow a transposition of the formula /1.1.4/ for water carrier systems into

$$\dot{Q} = \Delta P_{din} \cdot D^3 \cdot \pi/6 \ /W/ \qquad /1.1.8./$$

It is therefor sufficient to multiply the value of the measured differential pressure $\Delta P_{din}$ in the data processing stage by $D^3 \cdot \pi/6$ to give the amount of the consumed heat energy. If the differential pressure is measured in a pipe supplying a dwelling, the diameter is also a constant value so that only a single DC-signal of constant value is needed; the data processing stage will need only a single DC-signal source and a very simple one since no adjusting of the level is needed. Such a heat consumption meter will only incur an extremely small space and expense requirement. If the measuring is performed at a central unit supplying the fluid over pipes of different cross-section or a meter is wanted that may be adjusted to different heat exchengers or work-

ing conditions or a meter is wanted deriving different kinds of data from the measured quantity, a single DC--signal sources to provide different constant values for alternative or combined use in the data processing. In this case, the arithmetical stage will always receive as many different DC-signals as necessry to perform the processing of data which shall be transformed according to different system features. It can be seen that the method according to the invention is a very flexible one. It may be performed in a very simple manner and using a very simple and inexpensive device if only one quantity shall be derived from the measured value under practically constant working conditions and it can be performed providing manifold combinations of wanted informations where the data processing may comprise plenty of steps and the devices may be aggregates including different type units and stages and even different quantities of the different components, respectively. The method is apt to provide any data for billing and keeping evidence and also for generating signals for a process control intending the optimization of supply, consumption, and expenditure.

The mathematical relations between the different kinds of data needed for the working and billing in waterworks can be used in a similar way as the ones discussed hereinabove. It is also in this case necessary to produce a formula comprising only a single independent variable, viz. the same dynamic differential pressure. The pressure transmitter is applied in the pipe section ending in a water-tap. As far as the water-tap is closed and even no casual dropping is occurring, the column of fluid is in rest and the pressure is including no dynamic component. The pressure measured in two different cross-sections of the said pipe section will be equal, the difference will be zero:

$p_1 = p_2 = p_0$ and $\Delta p_{din} = 0$. Once a fluid flow has started through the water-tap, the mass flow in the two cross-sections will obviously be equal but the pressure values measured in the different cross-sections will be different:

$\dot{m}_i = \rho_i \cdot A_i \cdot v_i$. where $i = 1$ or $2$;
$\rho_1 = \rho_2$; $A_1 = A_2$; $\dot{m}_1 = \dot{m}_2$ but $p_1 \neq p_2$ rather
$/p_1 - p_2/ = \Delta p_0 = v^2/2$ so that: $v = \sqrt{2 \cdot \Delta p_0}$.

Let us incorporate all constant values but for the diameter of the pipe into a common constant value system factor to give $\dot{m} = 0{,}785 \cdot \sqrt{2 \cdot d \cdot \Delta p_0}$.

The pipe section having a length L and lying between the first and the second cross-section coupled with the sensors of the pressure transmitter may be considered a pressure tube wherefrom the data to be processed may be obtained. The pressure transmitter may in this case comprise, e.g. a suitably shaped membrane following the dynamic changes of the pressure in a linear manner and not subjected in the working range to any restricting conditions such as a threshold value. If taking into consideration the different members of the membrane equation, the modulus of flexibility and its effect on inclination, the dimensions of the membrane, and supposing that the movement of the membrane remains within the range of elasticity the well-known inclination formula may be transposed to comprise only a single independent variable, viz. the dynamic differential pressure whereas all other parameters may provided that suitable restrictions are complied with the converted into real constant value factors and incorporated into a resulting constant value system factor. In the case of using a membrane, the distance between the first and the second cross-section to be tapped by the sensors of the pressure gauge is expediently chosen as a function of the diameter of the pipe: $L \sim 0{,}36 \cdot D$. In this case, the

differential pressure measured in a pipe of a diameter not exceeding 60 mm will certainly not exceed 0,1 bar a value much less than the threshold value of $P_{max} = 6$ bar allowed for the so-called low-pressure pipes. One DC-signal source of the data processing unit will therefor supply a voltage proportional to the dimensionless system factor: 0,785 whereas another one will supply a voltage proportional to the diameter of the pipe. If, however, the differential pressure is measured in a pipe section ending in a water-tap of a dwelling, the value of the diameter is also an unchanging constant value so that a single DC-signal is needed for the data processing representing a combination of the dimensionless value 0,785 and the given pipe diameter. A suitable calibration of the data storing and display devices coupled with the arithmetical stage is sufficient to obtain the water consumption in all stages in the usual dimension: $m^3$.

WHAT WE CLAIM IS:

1. A method for measuring the consumption of fluids or fluid-borne heat energy supplied over a pipe system and recording and/or displaying the data obtained by the measurement and/or further processing same, c h a r a c t e r i z e d i n that sensors of a differential pressure gauge /hereinafter: pressure transmitter/ are coupled to the wall of the fluid transporting pipe at two characteristic cross-sections /e.g. at the fluid input and output of a heat exchanger or at two cross-sections lying near to each other of a pipe section ending in a water tap/; the output signals of the said pressure transmitter are read into a data processing device performing a data conversion according to the known relations between differential pressure and the wanted data; and the processed signals are read into data recording and/or display devices calibrated in the dimension of the wanted data and/or transmitted towards external data processing and/or process control devices.

2. A consumption meter for measuring the supply of fluids or fluidborne heat energy over pipes, c h a r a c t e r i z e d i n that it comprises at least one differential pressure gauge /hereinafter pressure transmitter/ /311/ equipped with coupling means for connecting its sensors to the wall ofthe fluid transporting pipe; a data processing unit /131, 132, 23/ equipped with data conversion means working according to the known relations between differential pressure and the wanted consumption data and with coupling means adapted to the output/s/ of the said pressure transmitter/s/ /311/; and a data recording and/or dispalying device equipped with coupling means adapted to the output/s/ of the said data processing unit /131, 132, 23/; and the said meter is optionally equipped with one or more separate outputs apt for coupling it to external

data processing and/or process control devices.

3. A consumption meter as claimed in claim 2 wherein the data processing unit /131, 132, 23/ comprises an arithmetical stage /32/ connected over its input/s/ to one or more DC-signal sources /312, 313, 314/ and - directly or indirectly - to the output/s/ of the said pressure transmitter/S/ /311/ and over its output to an A/D converter such as voltage/pulse train converter /33/.

4. A consumption meter as claimed in claim 3 wherein the data recording means is a numerical data recorder /35/ equipped with or coupled to a numerical display device /36/ and an instant value display /37/ is preferably coupled to the output of the said data processing unit /131, 132, 23/ or the A/D converter /33/.

**AMENDED CLAIMS**
(received by the International Bureau on 17 March 1983 (17.03.83))

1 (amended). A method for measuring the consumption of fluid-borne heat energy supplied over a pipe system and recording and/or displaying the data obtained by the measurement and/or further processing same, characterized in that sensors of a differential pressure gauge /hereinafter: pressure transmitter/ are coupled to the wall of the fluid transporting pipe at two characteristic cross-section /e.g. at the fluid input and output of a heat exchanger/; the output signals of the said pressure transmitter are read into a data processing device performing a data conversion according to the known relations between differential pressure and the wanted data; and the processed signals are read into data recording and/or display devices calibrated in the dimension of the wanted data and/or transmitted towards external data processing and/or process control devices.

2 (amended). A consumption meter for measuring the supply of fluid-borne heat energy over pipes, characterized in that it comprises at least one differential pressure gauge /hereinafter pressure transmitter/ (311) equipped with coupling means for connecting its sensors to the wall of the fluid transporting pipe: a data processing unit (131, 132, 23) equipped with data conversion means working according to the known relations between differential pressure and the wanted consumption data and with coupling means adapted to the output/s/ of the said pressure transmitter/s/ (311); and a data recording and/or displaying device equipped with coupling means adapted to the output/s/ of the said data processing unit (131, 132, 23); and the said meter is optionally equipped with one or more separate outputs apt for coupling it to external

data processing and/or process control devices.

3. A consumption meter as claimed in claim 2 wherein the data processing unit /131, 132, 23/ comprises an arithmetical stage /32/ connected over its input/s/ to one or more DC-signal sources /312, 313, 314/ and - directly or indirectly - to the output/s/ of the said pressure transmitter/S/ /311/ and over its output to an A/D converter such as voltage/pulse train converter /33/.

4. A consumption meter as claimed in claim 3 wherein the data recording means is a numerical data recorder /35/ equipped with or coupled to a numerical display device /36/ and an instant value display /37/ is preferably coupled to the output of the said data processing unit /131, 132, 23/ or the A/D converter /33/.

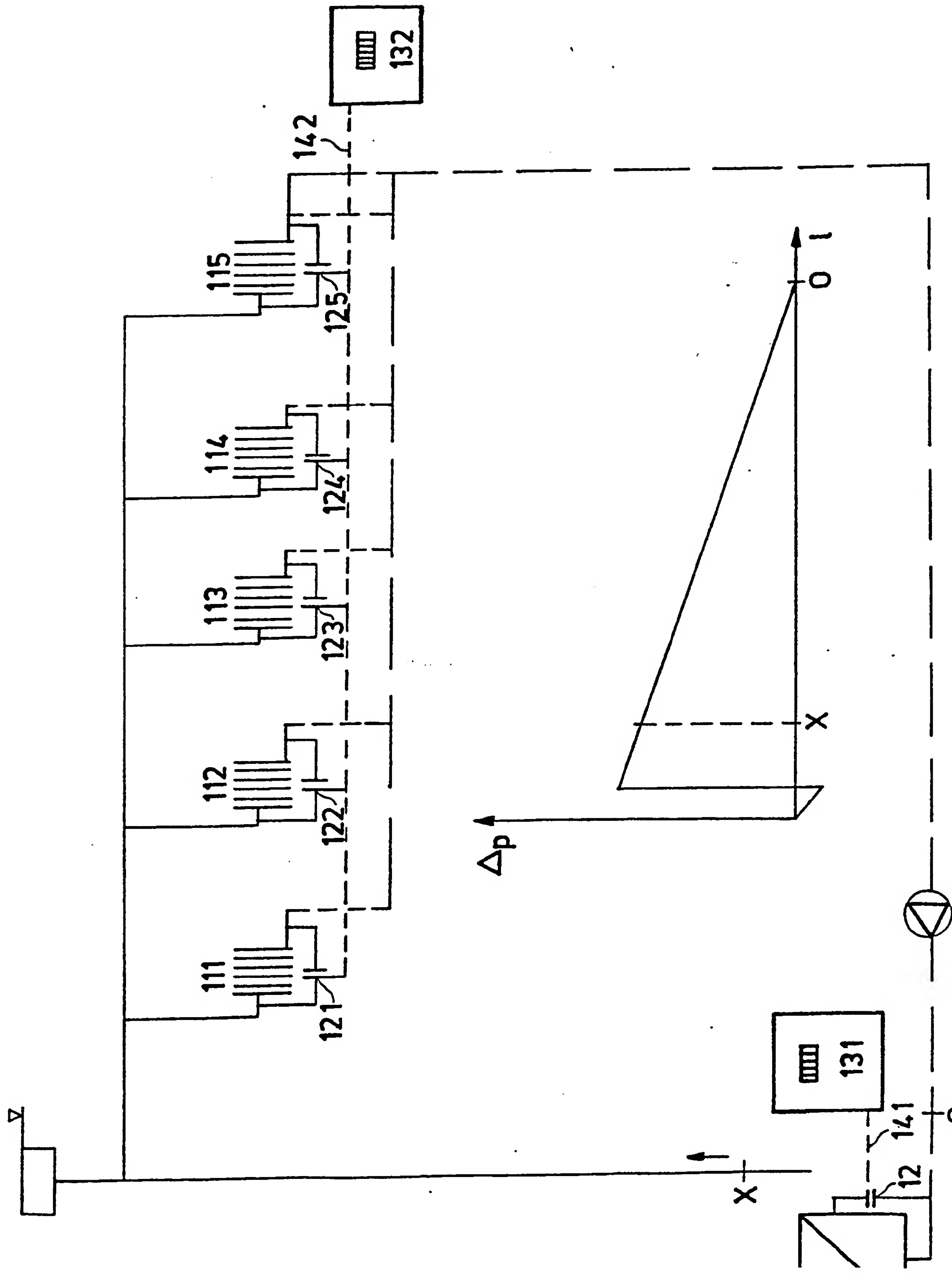



Fig.1

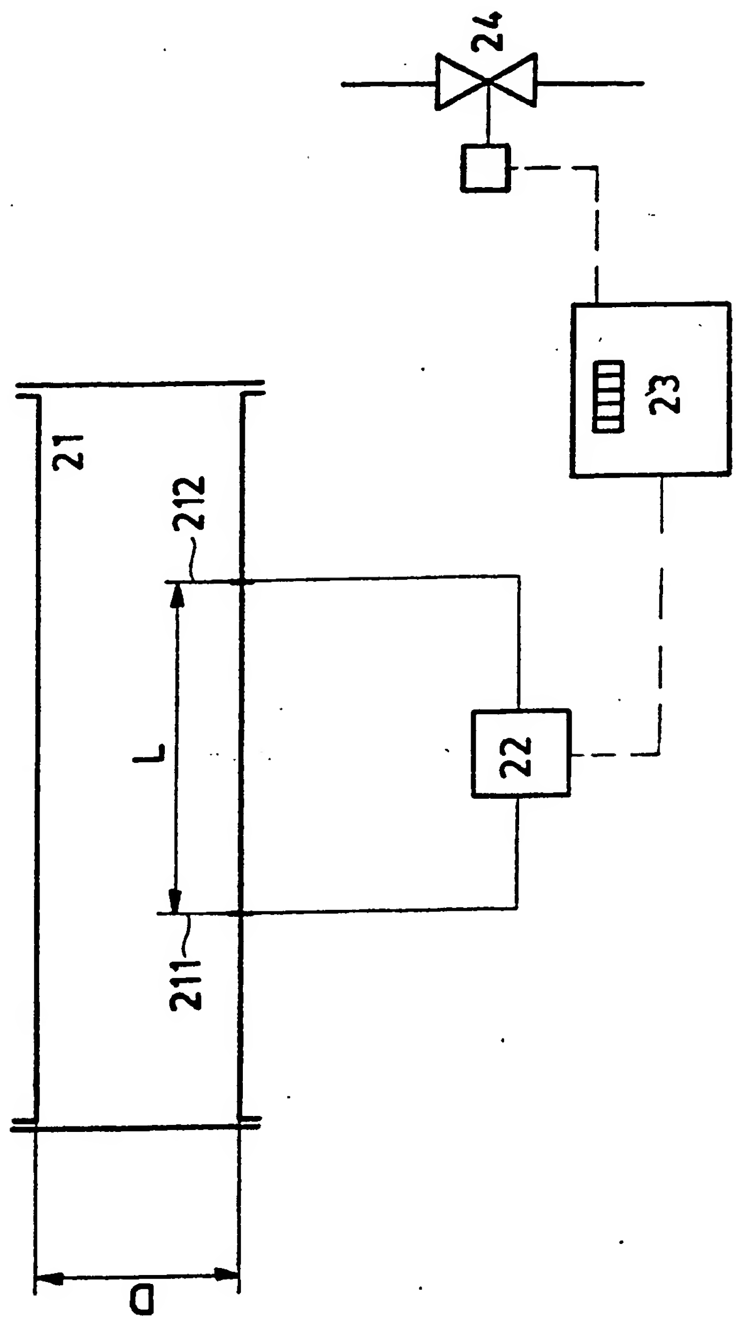



Fig. 2

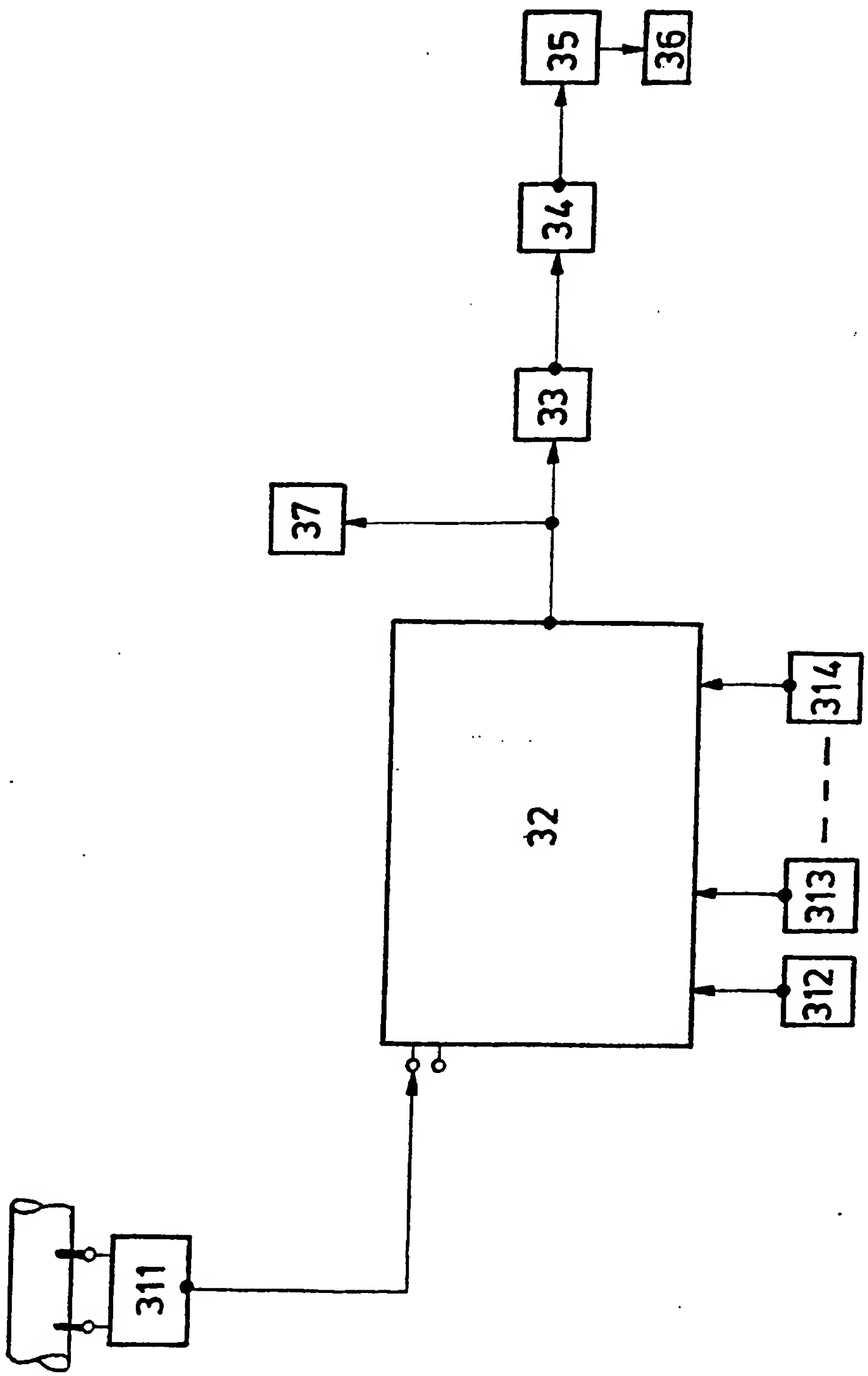



Fig. 3